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## Expected Loss Development in Workers' Compensation Pricing: A Shift in Credibility

Christopher J. Poteet\*

### Abstract<sup>†</sup>

This paper shows that expected loss development is equivalent to adjusting the full credibility standard and applying credibility by policy period. Expected loss development should not be used in workers' compensation ratemaking. The credibility is correct before being adjusted.

Key words and phrases: *formula pure premium, ultimate loss development*

### 1 Introduction

Concerns with the current loss development method used in workers' compensation class ratemaking have been raised by Lamb (1993). If a class has zero losses at a first report, using a first to ultimate loss development factor produces zero ultimate losses as well. One possible solution is to use expected loss development. To simplify the illustration, assume that all losses are at the same benefit level, etc. The other factors easily can be taken into account later. Also for simplicity assume that there is only one policy period used and national pure premiums are not used. The following arguments then will be extended to include more policy periods and the use of national pure premiums.

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Workers' compensation classification ratemaking relies on several estimates of class pure premiums. One estimate is based on the latest available data for the class and state. This is called the *indicated pure premium*. Another estimate is the pure premium underlying current rates brought to the level of the indicated pure premiums. This estimate is called the *present on rate level pure premium*. A third estimate is a *national pure premium* which includes data from other states adjusted to reflect conditions in the reviewed state. These estimates are combined using *credibility weights*<sup>1</sup> to produce the *formula pure premium*. The formula pure premium is defined as follows:

$$\text{Formula Pure Premium} = \frac{\text{Formula Pure Premium Losses}}{\text{Payroll}/100}. \quad (1)$$

The objective of this paper is to show that using expected loss development will yield the same formula pure premium as obtained by adjusting the credibilities.

## 2 Determining Formula Pure Premium

### 2.1 One Year Losses

In order to determine the formula pure premium, we must determine the losses. Using expected loss development, initially the expected loss  $E$  (the present on-rate level pure premium multiplied by the payroll in hundreds) is the estimate of ultimate losses that is used to calculate the indicated pure premium. At a first report the actual losses  $A$  that have emerged can replace the losses that were expected to have emerged, namely  $(1/D) \times E$ , where  $D$  is the first to ultimate loss development factor. If the development factor is less than one, the estimate of ultimate losses using expected loss development may be negative. Ultimate losses, however, cannot actually be negative. This points out a weakness in the expected loss development methodology.

Credibility weighting produces the losses used in the formula pure premium. Let  $L$  denote the losses and  $Z$  and  $(1 - Z)$  denote the credibility weights used in the formula pure premium. It follows that:

#### Expected Loss Development:

$$L = Z \left( A + \left( 1 - \frac{1}{D} \right) E \right) + (1 - Z)E$$

<sup>1</sup>Credibility weights are the relative credence (trustworthiness) assigned to each estimate. These weights are non-negative and sum to one.

$$= \left(\frac{Z}{D}\right) \times A \times D + \left(1 - \frac{Z}{D}\right) \times E. \quad (2)$$

**Current Method:**

$$L = Z \times A \times D + (1 - Z) \times E. \quad (3)$$

Equations (2) and (3) are equivalent where  $Z/D$  in equation (2) is substituted for  $Z$  in equation (3). (Note that  $Z$  does not change.) Using  $Z/D$  instead of  $Z$  is equivalent to changing the full credibility standard that already limits fluctuations of formula pure premiums to a desired amount. The expected loss development method relies less on actual losses and more on expected losses than the current method. The expected loss development method implicitly lowers credibility by  $1/D$ , when  $D > 1$ . Expected loss development is a shift in credibility, giving less weight to actual losses and more weight to expected losses.

The equation that shows that expected loss development is equivalent to changing the full credibility standard can be expanded to include more policy periods and national pure premiums. The relationship holds if the credibility of indicated data is calculated by policy period and the national credibility is allowed to remain unchanged as one switches from one method to the other.

## 2.2 A General Formula

It can easily be proved that the serious (or nonserious or medical) formula pure premium calculated using expected loss development is equal to the serious (or nonserious or medical) formula pure premium calculated using credibility by policy period, where the credibility one normally would use is divided by the policy period's development to ultimate factor and multiplied by a factor reflecting the contribution of the policy period's exposure to the total. These individual credibilities are used as weights for the indicated pure premiums calculated separately for each individual policy period. Let

- $m$  = Number of reports of losses;
- $A_i$  = Actual  $i$ -th report of losses,  $i = 1, \dots, m$ ;
- $D_i$  =  $i$ -th to ultimate loss development factor,  $i = 1, \dots, m$ ;
- $E_i$  = Ultimate expected losses for  $i$ -th report,  $i = 1, \dots, m$ ;
- $P_i$  =  $i$ -th report payroll in hundreds,  $i = 1, \dots, m$ ;
- $P$  =  $\sum_{i=1}^m P_i$ ;

- $Z$  = State-indicated credibility weight;
- $Z_n$  = National credibility weight;
- $P^{(n)}$  = National pure premium;
- $P^{(e)}$  = Present on rate level pure premium; and
- $P^{(f)}$  = Formula pure premium.

In practice, we define  $E_i$  as follows:

$$E_i = P^{(e)} \times P_i \quad \text{for } i = 1, \dots, m. \quad (4)$$

For the expected loss development method,  $P^{(f)}$  is defined to be

$$P^{(f)} = \frac{Z}{P} \sum_{i=1}^m \left( A_i + \left(1 - \frac{1}{D_i}\right) E_i \right) + Z_n P^{(n)} + (1 - Z - Z_n) P^{(e)}. \quad (5)$$

After some elementary algebra and rearranging terms, we have

$$P^{(f)} = \sum_{i=1}^m \left( \frac{Z P_i}{D_i P} \right) \left( \frac{A_i D_i}{P_i} \right) + Z_n P^{(n)} + \left( 1 - Z_n - \sum_{i=1}^m \left( \frac{Z P_i}{D_i P} \right) \right) P^{(e)}. \quad (6)$$

On the other hand, for the current method,

$$P^{(f)} = \sum_{i=1}^m Z \left( \frac{A_i D_i}{P} \right) + Z_n P^{(n)} + (1 - Z_n - Z) P^{(e)}. \quad (7)$$

### 3 An Example

The following example is a specific illustration of the equivalence relationship. The example uses the data from Lamb (1993, Exhibit 1) and the development factors listed on page 321 of Lamb's paper. The state credibilities in the paper are calculated using a square root rule instead of NCCI's old two thirds rule—the serious state credibility of 0.67 is equal to 0.59 to the three fourths power [ $0.67 = (0.59^{3/2})^{1/2}$ ].

Suppose we are given the following information  $m = 3$ ,  $Z = 0.67$ ,  $Z_n = 0.16$ ,  $P^{(n)} = 1.287$ , and  $P^{(e)} = 1.203$  and the data in Table 1. Using equations (4) and (5) yields the formula pure premium  $P^{(f)} = 1.221$ . Alternatively, we can use Table 2 and equation (6) to derive the same result, i.e.,  $P^{(f)} = 1.221$ .

Our example focuses on the calculation of the serious formula pure premium. More recent years have higher development factors, so credibility is lowered more for them. Each year's credibility also is multiplied by a weight equal to the year's proportion of exposure to the total of all years. More recent years would tend to have higher exposures due to wage inflation, all else constant.

**Table 1**  
**Data**

$i$	$A_i D_i$	$D_i$	$P_i$
1	1,731,862	3.773	435,476.49
2	145,463	1.993	497,284.62
3	393,906	1.417	426,167.48

**Table 2**  
**The Alternative Approach**

$i$	$(ZP_i)/(D_i P)$	$A_i D_i / P_i$
1	0.057	3.977
2	0.123	0.293
3	0.148	0.924

## 4 Conclusions

Expected loss development can be thought of as a shift in credibility from the indicated pure premiums to the present on-rate-level pure premium. (See Table 3.) Expected loss development relies heavily on the present on-rate-level pure premium, whereas the new NCCI full credibility standard and partial credibility formula give equal weight to the present on-rate-level pure premium and the national pure premium.

NCCI now uses higher full credibility standards and a 0.4 power partial credibility formula to recognize the need for stability. The credibility given to the indicated data using the new NCCI standard and formula is about the same as the credibility for expected loss development, therefore limiting fluctuations by about the same amount as expected loss development. An advantage to the expected loss development scheme is the consideration of different credibilities by policy period.

Expected loss development should not be used in workers' compensation class ratemaking. Expected loss development is equivalent to adjusting credibility. An extensive study was performed by NCCI to develop new full credibility standards and a partial credibility formula that provides a desirable balance between stability and responsiveness. Adjusting these credibilities downward would restrict the fluctuations

**Table 3**  
**Credibilities**

Serious Pure Premium	Indicated	National	PORL
Current Loss Development	0.67	0.16	0.17
Expected Loss Development	0.33	0.16	0.51
New NCCI Standard & Formula	0.38	0.31	0.31

*Notes:* PORL = Present on Rate Level

in formula pure premiums and make rate changes less responsive. This is especially undesirable in states that have undergone major workers' compensation benefit reforms in recent years. One might argue that more recent years should receive less credibility than older years because more recent data are less mature. On the other hand, responsiveness to a changing workers' compensation environment would be sacrificed.

## References

- Lamb, R.M. "Partial Loss Development Based On Expected Losses For Workers' Compensation Class Ratemaking." In *Casualty Actuarial Society Forum*, Special Edition, Ratemaking Call Papers, 1993: 313-340.